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U. S. ARMY
TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

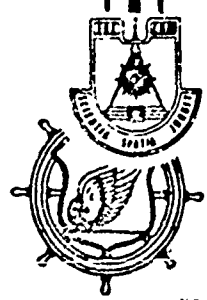
TCREC TECHNICAL REPORT 62-72

HELICOPTER STATIC-ELECTRICITY MEASUREMENTS

INTERIM REPORT

Task 9R38-01-017-30

June 1962



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DEPARTMENT OF THE ARMY

TRANSPORTATION CORPS

INTERIM REPORT

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June 1962

by

James M. Seibert

U. S. ARMY TRANSPORATION RESEARCH COMMAND

Fort Eustis, Virginia

CONTENTS

SUMMARY

This is a report on the in-house static-electricity measurements program conducted by the U. S. Army Transportation Research Command (USATRECOM). Measurements were made at the Arctic Test Board, Fort Greely, Alaska; the Aviation Board, Fort Rucker, Alabama; and the U. S. Army Transportation Materiel Command (USATMC) Flight Test Office, Edwards Air Force Base, California.

The highest voltage accumulation was measured at the Arctic Test Board, with downwash blowing snow in the rotor blade path. Personnel from the Arctic Test Board report that conditions which produce maximum voltage accumulation in the Arctic were not encountered.

Measurements made at Fort Rucker, Alabama, were of the same magnitude as those obtained during other measurements under similar conditions.

The data obtained at Edwards Air Force Base, California, indicate that there is a larger current generation and voltage accumulation during operations in blowing dust than is experienced in relatively clear air.

The maximum voltage accumulation measured on this program was 200,000 volts, and the maximum charging current was 50 microamperes.

CONCLUSIONS

It is concluded that:

1. Particles present in the air and coming in contact with helicopter rotor blades while the helicopter is in flight cause an increase in the static-electricity charging current and result in an increase in the accumulated voltage on the helicopter.

2. The maximum voltage and maximum charging current measured in this program are not to be considered the maximum which may be encountered. It would be unwise to expect that maximum charging conditions were encountered during this short period.

BACKGROUND

The expanding role of the helicopter in military operations presents new problems, one of which is the generation and accumulation of static electricity by the helicopter while in flight. The helicopter is now being used for external cargo operations and is required to be in the vicinity of ground personnel and equipment while hovering. The presence of high electrostatic potentials on the helicopter during operations such as external cargo hookups, air-sea rescue work, etc., presents serious safety hazards. Electrostatic discharge in the form of an arc could cause injury to ground personnel performing ground hookups and to persons involved in air-sea rescue; in addition, fuel vapors present in the vicinity of the discharge arc could be ignited. Externally loaded cargo such as fuel, munitions, and electronic components may be adversely affected by the sudden discharge of electrical energy through them. Verbal reports of injury to ground personnel and ignition of fuel slicks in the ocean have been received.

To date, considerable static-electricity work has been done through USATRECOM contracts with Princeton University, Cornell Aeronautical Laboratory, Inc. (CAL), and Kellett Aircraft Corporation. The majority of this work has been directed toward devising suitable means of dissipating an accumulated static charge.

Since it is known that atmospheric variations affect the charging current and voltage accumulations of helicopters in flight, it was decided to conduct an in-house program to obtain more definitive information about atmospheric effects on helicopter static electricity. The scope of this program was increased in response to a U. S. Continental Army Command request to support U. S. Army Airborne, Electronics and Special Warfare Board Project 1860 with information pertaining to maximum voltage accumulations on Army helicopters.

The data gathered during this program will have two primary uses: first, they will be used to assist in determining requirements for discharge systems, since charging current is of primary importance in establishing discharger capabilities; secondly, the voltage data will be used in conjunction with the capacitance of the helicopter to determine the amount of electrical energy available for discharge through an external load.

Although the data obtained to date indicate that there are high voltage accumulations and charging currents on helicopters, measurements are continuing in an effort to obtain data under more extreme conditions.

DISCUSSION

GENERAL

The locations of the helicopters of primary concern in this program (H-37, H-34, H-21, H-19, and HU-1) were determined and combined with the information about the general atmospheric conditions of the locations. Requests for support of the program were sent to installations where the conditions of interest existed. In all cases, these requests were favorably received.

Commercial measuring equipment capable of meeting all the anticipated electrical requirements and suitable for airborne operations could not be located. Some low-voltage measurements were made with a Kiethley Model 220 vacuum-tube voltmeter; a USATRECOM-developed device employing concentric spheres with a Kiethley Model 600A electrometer was used for higher voltage measurements. The current measurements were taken with a -50, 0, +50 microammeter. A typical test setup employing the concentric spheres device and the microammeter is shown in Figure 1. The external field sensor built by CAL was used on the H-37B in addition to the equipment described above. This device does not require any connection to the ground and measures the electric field created around the aircraft by the voltage accumulation on the aircraft.

Arctic Test Board Measurements

Measurements were made on the HU-1A, the H-21, the H-34, and the H-37B at the Arctic Test Board, Fort Greely, Alaska, during the period 14-24 March 1962. The temperature at Fort Greely ranged from -32° F. to +19° F. during the testing period. No measurements were made in falling snow; however, measurements were made with snow being blown up by rotor downwash around the helicopter. Measurements were made on the H-37B employing the USATRECOM concentric spheres device, the

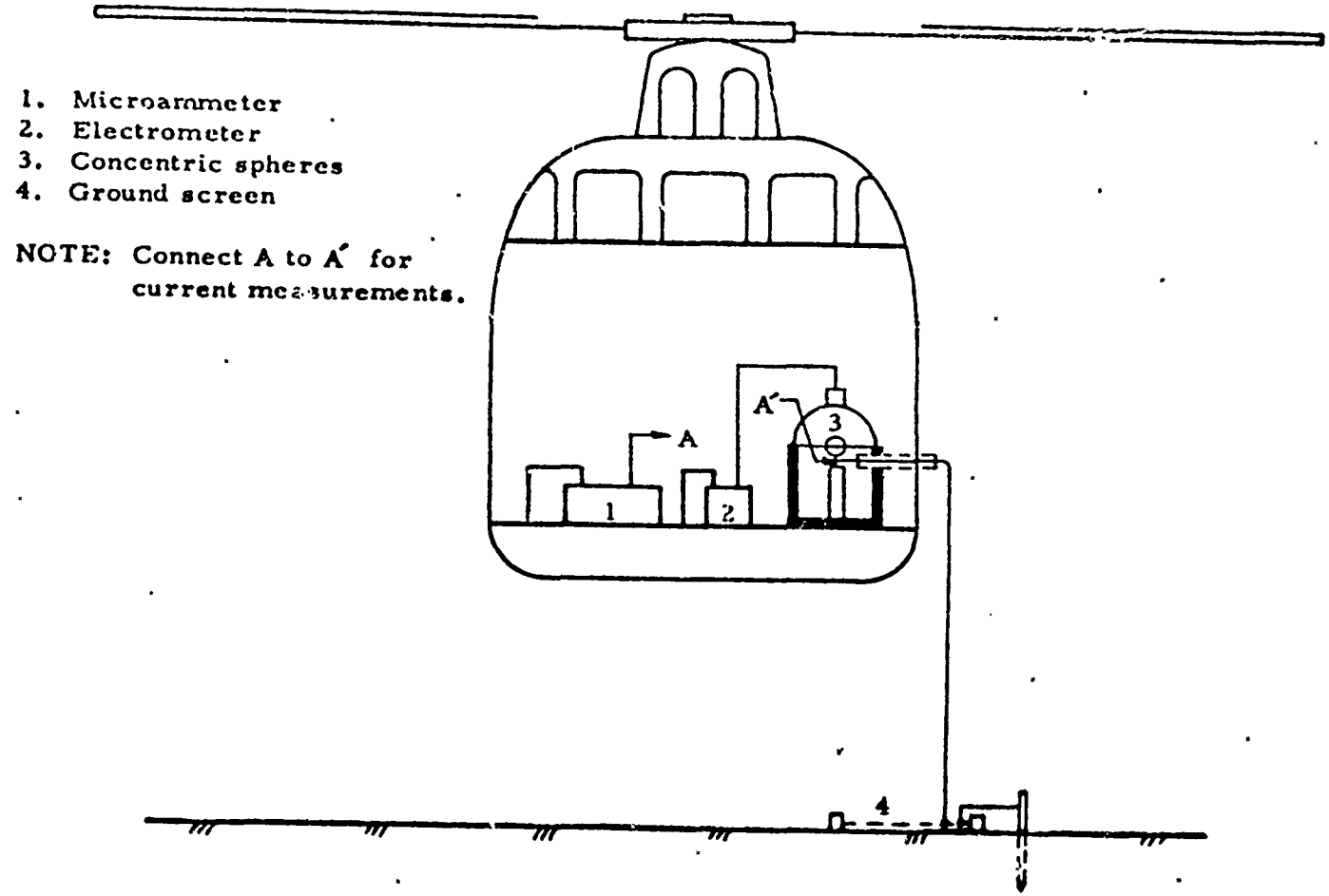

Figure 1. Typical Setup of Test Equipment.

microammeter, and the CAL external field sensor. The maximum voltage accumulation observed was during a hover over loose snow at the Fort Greely airport. The aircraft was hovered approximately 25 feet above the ground. Measurements indicating a -200,000-volt charge on the aircraft were taken from the CAL field sensor prior to the time that the ground line was dropped out of the cargo compartment door. A value this high was not obtained after the ground line was dropped to the ground screen because the concentric spheres device had a voltage breakdown limitation of 166,000 volts. Indications were that an arc-over occurred between the spheres at this time. The maximum current was measured while the aircraft was hovering over a 5,440-foot mountain top. The aircraft was hovering approximately 10 feet above the mountain and was blowing small amounts of loose, fine snow into the rotor blades. Current as high as 50 microamperes was measured. This value represents the highest current measured on an H-37 during the entire USATRECOM program. Additional readings were taken on the helicopter at Fort Greely. (See Figure 2.)

Static electricity on the HU-1A helicopter was measured with the vacuum-tube voltmeter and the microammeter both while the craft was hovering over a frozen lake on which there were large amounts of loose snow and while it was hovering over the airfield. The highest readings were obtained over very loose snow with the aircraft moving continually to keep the snow blowing in the rotor-blade path. The charging current reached a maximum of 32 microamperes; the voltage, a maximum of approximately 30,000 volts. Numerous tests were conducted in an effort to determine the effectiveness of the ARC/44 transmitter as a means of dissipating static electricity (the HU-1A operating manual states that this transmitter may be used to dissipate static electricity). The operation of this transmitter appeared to have no effect on the charging rate or the accumulated voltage on the aircraft.

A summary of the maximum voltage and current readings obtained in Alaska is given in Figure 2. These data do not necessarily represent the highest readings obtainable under arctic conditions; they are merely a listing of the actual values obtained under the conditions found near Fort Greely during the time that these measurements were made.

It appears that the presence of snow blowing through the rotors is a major factor in the charging rate and accumulation. Arctic Test Board personnel have verbally reported that voltages higher than those measured under this program have been indicated by arcs during external hookups in periods of prolonged extremely low temperature. Such low-temperature conditions were not experienced during the period 14-24 March 1962.

Army Aviation Board Measurements

Measurements were made at the U. S. Army Aviation Board, Fort Rucker, Alabama, during the period 9-13 April 1962. Aircraft on which measurements were made included the H-19, the H-21, the H-34, the H-37B, the HU-1A and the HU-1B. The weather was clear, with the temperature ranging in the 70's and 80's during measurements on all the helicopters except the H-34 and H-19; for these, the temperature was in the 60's. The aircraft were flown to a small landing strip near Fort Rucker, where the ground screen was placed over hard-packed clay. A very small amount of loose, red clay was blowing around from the downwash while the H-37B was hovered over the ground screen. Maximum readings are shown in Figure 2.

USATMC Flight Test Office Measurements

At Edwards Air Force Base, California, voltage and current were measured on the HU-1, the H-21, the H-37, and the Marine Corps HUS-1 (which is comparable to the Army H-34). Measurements were taken on all the aircraft both over a concrete ramp and over the sand in the desert. During the measurement period (6-12 May 1962), the weather was clear, with winds from 10 to 20 knots and temperatures in the 50's to 70's. The maximum values obtained over the concrete ramp as well as those obtained over the sand surface are shown in Figure 2.

Some difficulty was experienced in blowing sand up into the rotor path. The aircraft were hovered as low as 1 foot from the ground in an effort to blow up as much sand as possible into the rotors. Pilots have indicated that at times dust and dirt will blow up so that the ground cannot be observed from the helicopter. This was not experienced during the measurement period.

PRESENTATION OF DATA

Figure 2 is a summary of the data accumulated during the in-house program described in this report. In many cases, the maximum voltage accumulation is listed as two values for the same helicopter at a single location. This is intended to point out variations in both voltage accumulation and charging current as atmospheric conditions are changed. These changes are noted in the "remarks" column.

Helicopter Type	Maximum Voltage and Polarity (Volts)	Current (Microamperes)	Location	Remarks
H-37B	- 50,000	5 to 11	Ft. Greely	Over water and packed snow
H-37B	-200,000	45 to 50	Ft. Greely	See pages 5 and 6
H-37B	+ 60,000	1 to 1.5	Ft. Rucker	Over red clay
H-37B	+ 55,000	3	Edwards AFB	Over concrete
H-37B	(Not measured)	22	Edwards AFB	Blowing dirt
H-34C	- 40,000	.5 to 2.5	Ft. Greely	Blowing snow
H-34C	+ 1,100	.25 to 1	Ft. Rucker	Over red clay, clear
H-34C	+ 100	Very low	Ft. Rucker	Damp - overcast, over red clay
HUS-1	+ 1,200	Very low	Edwards AFB	Over concrete
HUS-1	+ 6,000	-7 to +4	Edwards AFB	Over dirt
H-21C	- 20,000	2.5	Ft. Greely	Blowing light snow
H-21C	+ 1,300	.25	Ft. Greely	Over packed snow
H-21C	+ 1,000	.25 to .5	Ft. Rucker	Over red clay
H-21C	+ 2,000	Very low	Edwards AFB	Over concrete
H-21C	+ 8,000	- 4	Edwards AFB	Over dirt
H-19	+ 1,100	-.25 to +.25	Ft. Rucker	Over runway
HU-1A	+ 1,200	.25	Ft. Greely	Over snow but not blowing up
HU-1A	- 30,000	18 to 32	Ft. Greely	Large amount of blowing snow
HU-1A	+ 20,500	-.5 to +1	Ft. Rucker	Over red clay
HU-1B	+ 1,500	.5	Ft. Rucker	Over red clay
HU-1	+ 1,600	Very low	Edwards AFB	Over concrete
HU-1	+ 5,000	6	Edwards AFB	Over dirt

Figure 2. Presentation of Data.

It should be noted that one flight over blowing dirt at Edwards Air Force Base indicates "not measured" in the "voltage-accumulated" column. This is a result of difficulties experienced in maintaining the condition of dust blowing in the rotor path. The current was measured while an attempt was made to create the blowing-dirt condition.

In the "current" column, it should be noted that variations are indicated. These are due to variable readings and point out that steady values were not always obtained. The indication of "very low" points out that the current is not of sufficient magnitude to be read from the meter. In a few cases, the current changed polarity, as indicated, and was usually very erratic in its changing.

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HELICOPTER STATIC-ELECTRICITY MEASUREMENTS, by James M. Seibert, Interim rept. on Task 9R38-01-017-30, June 62, 9 p. incl. illus. (TCREC technical rept. 62-72)

Unclassified report

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(over)

1. Static Electricity on Helicopters
2. Helicopters--Static-Electricity Generation

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